

Azetidine derivatives, method for producing said
derivatives and use thereof

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Description

The present invention relates to azetidine derivatives,
to methods for producing them, and to their use as a
latent curing component for resins having functional
10 groups which are reactive toward amines, especially
polyurethane resins and polyepoxide resins.

Latent curing components are used in particular for
moisture-curing polyurethane compositions in the
15 production of sealants, adhesives, and coating
materials. In the prior art a whole series of latent
curing agents have already been described, but they all
have the serious disadvantage that the curing reaction
is accompanied by release of volatile organic compounds
20 which either pollute the environment and/or appear
problematic from a health standpoint.

For instance, DE-A 30 19 356 describes, as curing
agents for polyisocyanates, compounds which contain
25 aldimine groups and oxazolidine groups and are prepared
by a) reacting polyamines with an epoxide compound and
b) subsequently cyclizing the polyamino alcohols,
formed in stage a), with aldehydes. When these
aldiminooxazolidines are cured with polyisocyanates, in
30 the presence of water or atmospheric moisture,
aldehydes are eliminated which in some circumstances
represent a severe odor nuisance and can therefore be
used only in the outdoor sector.

35 DE-A 36 24 924 discloses moisture-curing, storage-
stable, one-component polyurethane systems which in
addition to the polyurethane prepolymer include, as a
component essential to the invention, a polyaldimine as

- curing agent. With these polyurethane systems as well, aldehydes are eliminated in the course of curing, and so use for the interior sector is ruled out from the outset. A further disadvantage associated with these polyurethane systems is the fact that the corresponding polyurethane prepolymers have a relatively high viscosity, so that diethyl malonates must be added in order to reduce the viscosity.
- 10 In accordance with DE-A 40 21 659, bisoxazolanes are recommended as curing agents for polyurethane systems, and are prepared by reacting diethanolamine with aldehydes. Although solvent-free products of low viscosity can be provided in this way, these
- 15 bisoxazolanes give off two moles of aldehyde per mole of curing agent in the course of the curing reaction, and such elimination is associated with the disadvantages already described above.
- 20 Moreover, in EP-A 291 850, one-component polyurethane systems are described which in addition to the polyurethane prepolymer include a latent curing agent from the group consisting of oxazolidines, enamines, and azomethines, preferably ketimines and/or aldimines.
- 25 These compounds too give off unwanted aldehydes or ketones in the course of hydrolysis in the presence of moisture. Furthermore, in order to reduce the increase in viscosity, diethyl malonates must be added to the polyurethane prepolymers or one-component polyurethane
- 30 systems, in an amount of up to 10% by weight.
- WO 95/11 933 discloses aldimine-oxazolidines. Apart from the relatively complicated preparation, the release of aldehydes in the course of the curing
- 35 reaction of these compounds must be regarded as particularly disadvantageous.
- EP-A 947 529, finally, discloses polyurethane prepolymers which in addition to the isocyanate groups

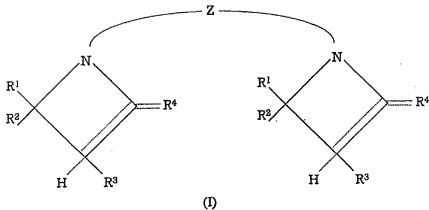
contain latent amino groups. These polyurethane prepolymers are prepared by addition reaction of an amino-aldimine or of a cycloaminal with the isocyanate group of a polyurethane polymer. With this polyurethane system as well the elimination of benzaldehyde in the course of the curing reaction assisted by water or atmospheric moisture is unavoidable.

The object on which the present invention was based, therefore, was to provide a latent curing component for resins containing amine-reactive functional groups that does not have the stated disadvantages of the prior art but instead does not eliminate any volatile organic compounds in the course of moisture-induced curing, possesses good performance properties, and can be prepared relatively easily and inexpensively.

This object has been achieved in accordance with the invention through azetidine derivatives of the general formula (I) according to claim 1.

It has surprisingly emerged that, with the curing component provided in accordance with the invention, no organic compounds at all are eliminated in the course of the curing reaction. Furthermore, the latent curing agents of the invention can be formulated effectively with all common isocyanate-functional and/or epoxy-functional systems, with the corresponding curing agent/resin reaction products exhibiting very good storage stability over a relatively long time period, which likewise was not foreseeable.

In accordance with the invention, as a latent curing component, an azetidine derivative of the general formula (I) is provided

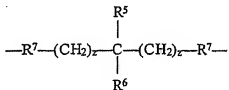


where

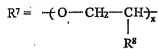
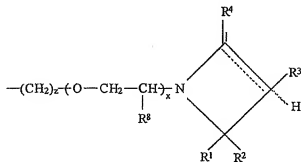
5 R^1 , R^2 and R^3 independently of one another are H, C_1-C_{20} alkyl, C_3-C_8 cycloalkyl, C_6-C_{10} aryl or alkylaryl with C_1-C_4 alkyl and C_6-C_{10} aryl groups

$Z = C_2-C_{25}$ alkylidene, C_5-C_{25} cycloalkylidene, C_6-C_{24} arylene and also

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R^5 and $R^6 = H, CH_2OH, C_1-C_4$ alkyl, C_6H_5 ,



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$R^3 = H, CH_3, C_2H_5, C_6H_5$

$z = 0 \text{ or } 1$

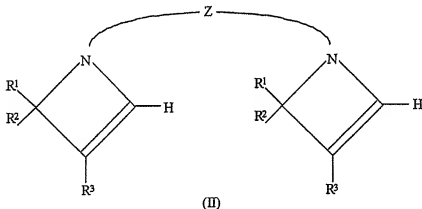
$x = 0 \text{ to } 100.$

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Preferred alkyl radicals, which may be either linear or branched, are C_1 to C_4 alkyl groups. With regard to the cycloalkyl radicals, cyclopentyl and cyclohexyl groups, and with regard to the aryl radicals, phenyl and naphthyl groups, are regarded as being preferred.

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One preferred embodiment uses, in particular, azetidine derivatives of the general formula (II)

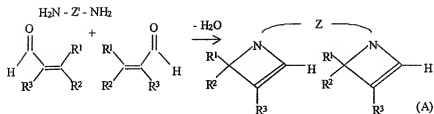


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where R^1, R^2, R^3 , and Z are as defined above. The azetidine derivatives of the formula (II) are very easily preparable by reaction of one mole of the polyamine of the formula $H_2N-Z'-NH_2$ with two moles of an α, β -unsaturated aldehyde of the formula $R^1R^2-C=CR^3CHO$ in accordance with equation (A), the cyclization to the bis-azetidine derivative taking place with elimination of water:

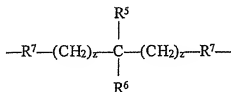
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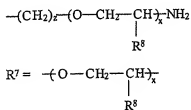


Z' here has the following definition:

- 5 C₂-C₂₅ alkylidene, C₅-C₂₅ cycloalkylidene, C₆-C₂₄ arylene, and



- 10 R⁵ and R⁶ = H, CH₂OH, C₁-C₄ alkyl, C₆H₅,

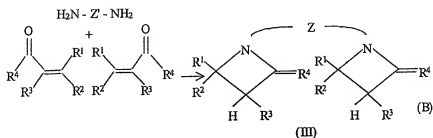


- R⁸ = H, CH₃, C₂H₅, C₆H₅
 15 z = 0 or 1
 x = 0 to 100

- Where the polyamine NH₂-Z'-NH₂ has three or four NH₂ groups, the corresponding tris- or tetrakis-azetidines
 20 can be prepared by reaction with three or four moles of the α,β-unsaturated aldehyde.

The reaction of one mole of the polyamine H₂N-Z'-NH₂ with two moles of an α,β-unsaturated ketone of the

formula $R^1R^2C=C-CR^3-COR^4$ in accordance with equation (B) produces bis-azetidine derivatives of the general formula (III):



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In the context of the present invention it is also possible for the polyamine $NH_2-Z'-NH_2$ to have three or four NH_2 groups. In these cases the corresponding tris- or tetrakis-azetidines are obtained by reaction of 10 or 1 mole of the polyamine with three or four moles of the α,β -unsaturated ketone $R^1R^2C=CR^3-COR^4$.

The production of the azetidine derivatives of the invention is relatively unproblematic and can take place by reaction of the polyamine with the α,β -unsaturated aldehyde or ketone in the presence of an organic solvent, especially toluene, in the temperature range from 20 to 150°C, in particular with removal of 20 water.

The diazepine derivatives provided in accordance with the invention are outstandingly suitable as a latent curing component for resins having functional groups 25 which are reactive toward amines. Latent curing components bring about moisture-induced curing.

The diazepine derivatives of the invention are preferably used for curing polyurethane resins and/or 30 epoxy resins.

In the context of the present invention, however, it is

readily possible to use the diazepine derivatives in association with other polymer systems, such as polyacrylates, for example, or with other polymer compounds which contain at least one amine-reactive group. In one preferred embodiment in this context the diazepine derivative of the formula I undergoes addition reaction, via the secondary amine, with the resin to be cured. On exposure to moisture the azetidine ring is then opened hydrolytically and the secondary amine which results in this case is able, finally, to react with the reactive functional groups of the resin to be cured.

This curing of the mixture composed of curing component and resin takes place preferably in the temperature range from 5 to 80°C, in particular at 10 to 60°C.

The amount of the curing component used is relatively uncritical, although on economic grounds it has proven particularly advantageous to use the azetidine derivative proposed in accordance with the invention in an amount of 0.01% to 150% by weight, in particular 0.1% to 20% by weight, based on the amount of the resin to be cured.

In view of the particular advantages of the curing component of the invention, such as effective producibility, high environmental friendliness (no volatile compounds are eliminated in the course of curing), and good storage stability of the resin/curing agent mixtures, azetidine derivatives of formulae (I) to (III) are outstandingly suitable for one-component, moisture-hardening polymer compositions, which are of special interest in particular for the production of sealants, adhesives, and coating materials, especially floor coating materials.

The examples below are intended to illustrate the invention in more detail.

Examples

All examples were produced with air exclusion in a nitrogen atmosphere.

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Example 1 A

Preparation of a bis-azetidine based on Jeffamin D-230

10 In a reaction vessel with water separator 30 g (0.306 mol) of mesityl oxide, 33.48 g (0.146 mol) of Jeffamin D-230 (Huntsman), and 0.1 g of p-toluenesulfonic acid are dissolved in 150 g of absolute toluene and the solution is heated to boiling. The reaction mixture is held at boiling temperature until
15 water can no longer be removed via the water separator (theoretical: 5.24 g of water). Subsequently the toluene is removed completely. This gives a slightly orange-colored, oily product.

20 Example 1 B

Production of an NCO-containing prepolymer with the bisazetidine curing agent derivative from Example 1A

25 In a reaction vessel 250 g (0.125 mol) of polypropylene glycol Dow Voranol P2000 (from Dow) are held with 55.55 g (0.25 mol) of isophorone diisocyanate and 0.1 g of T12-DBTL at 85°C until the theoretical NCO content of 3.44% by weight is reached.

30 Subsequently 48.0 g (0.123 mol) of bisazetidine derivative from Example 1A are stirred into 300.0 g of the NCO-containing prepolymer at room temperature.

The product obtained is resinous, is transparently clear, and possesses a weak orange coloration. Drawn down on a glass plate, it cures right through within a
35 short time without any unpleasant odor nuisance. Even in a high-build application, curing takes place right through.

Example 1 C

Production of an NCO-containing prepolymer with the bisazetidine curing agent derivative from Example 1A

- 5 In a reaction vessel 250 g (0.125 mol) of polypropylene glycol Dow Voranol P2000 (from Dow) are held with 43.54 g (0.25 mol) of toluene diisocyanate and 0.1 g of TI2-DBTL at 85°C until the theoretical NCO content of 3.58% by weight is reached.
- 10 Subsequently 40.0 g (0.102 mol) of bisazetidine derivative from Example 1A are stirred into 250.0 g of the NCO-containing prepolymer at room temperature. The product obtained is resinous, is transparently clear, and possesses a weak orange coloration. Drawn
- 15 down on a glass plate, it cures right through without any unpleasant odor nuisance. Even in a high-build application, curing takes place right through.

Example 2 A

- 20 Preparation of a bis-azetidine based on 1,6-hexamethylenediamine

- In a reaction vessel with water separator 30 g (0.306 mol) of mesityl oxide, 16.91 g (0.146 mol) of
- 25 1,6-hexamethylenediamine, and 0.1 g of p-toluenesulfonic acid are dissolved in 150 g of absolute toluene and the solution is heated to boiling. The reaction mixture is held at boiling temperature until water can no longer be removed via the water separator
- 30 (theoretical: 5.24 g of water). Subsequently the toluene is removed completely.

Example 2 B

- Production of an NCO-containing prepolymer with the
- 35 bisazetidine curing agent derivative from Example 2A

In a reaction vessel 250 g (0.125 mol) of polypropylene glycol Dow Voranol P2000 (from Dow) are held with 42.05 g (0.25 mol) of hexamethylene 1,6-diisocyanate

and 0.1 g of T12-DBTL at 85°C until the theoretical NCO content of 3.60% by weight is reached.

Subsequently 28.33 g (0.102 mol) of bisazetidine derivative from Example 2A are stirred into 250 g of the NCO-containing prepolymer at room temperature.

The product obtained is resinous, is transparently clear, and possesses a weak yellowish coloration. Drawn down on a glass plate, it cures right through without any unpleasant odor nuisance. Even in a high-build application, curing takes place right through.

Example 2 C

Production of an NCO-containing prepolymer with the bisazetidine curing agent derivative from Example 2A

In a reaction vessel 250 g (0.125 mol) of polypropylene glycol Dow Voranol P2000 (from Dow) are held with 65.59 g (0.25 mol) of H12MDI and 0.1 g of T12-DBTL at 85°C until the theoretical NCO content of 3.33% by weight is reached.

Subsequently 35.78 g (0.129 mol) of bisazetidine derivative from Example 2A are stirred into the NCO-containing prepolymer at room temperature.

The product obtained is resinous, is transparently clear, and possesses a weak yellowish coloration. Drawn down on a glass plate, it cures right through without any unpleasant odor nuisance. Even in a high-build application, curing takes place right through.

Example 2 D

Formulation of an epoxy-functional resin with the bisazetidine curing agent derivative from Example 2A

At 40°C 203.2 g (0.735 mol) of bisazetidine derivative from Example 2A are stirred homogeneously into 250 g (0.735 mol) of bisphenol A diglycidyl ether.

The product obtained is viscous, is transparently clear, and possesses a weak yellowish coloration. Drawn

down on a glass plate, it cures right through without any unpleasant odor nuisance.

Example 3 A

- 5 Preparation of a tris-azetidine based on Jeffamin T-403

In a reaction vessel with water separator 30 g (0.306 mol) of mesityl oxide, 45.85 g (0.102 mol) of Jeffamin T-403 (Huntsman), and 0.1 g of p-toluene-sulfonic acid are dissolved in 150 g of absolute
10 toluene and the solution is heated to boiling. The reaction mixture is held at boiling temperature until water can no longer be removed via the water separator (theoretical: 5.50 g of water). Subsequently the
15 toluene is removed completely. This gives a slightly orange-colored, resinous oil.

Example 3 B

- Production of an NCO-containing prepolymer with the
20 trisazetidine curing agent derivative from Example 3A

In a reaction vessel 250 g (0.125 mol) of polypropylene glycol Dow Voranol P2000 (from Dow) are held with 42.05 g (0.25 mol) of hexamethylene 1,6-diisocyanate
25 and 0.1 g of T12-DBTL at 85°C until the theoretical NCO content of 3.60% by weight is reached.

Subsequently 57.66 g (0.0835 mol) of trisazetidine derivative from Example 3A are stirred into the NCO-containing prepolymer at room temperature.

- 30 The product obtained is resinous, is transparently clear, and possesses a weak orange coloration. Drawn down on a glass plate, it cures right through without any unpleasant odor nuisance. Even in a high-build application, curing takes place right through.

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Example 3 C

Formulation of an epoxy-functional resin with the trisazetidine curing agent derivative from Example 3A

At 40°C 338.26 g (0.490 mol) of trisazetidine derivative from Example 3A are stirred homogeneously into 250 g (0.735 mol) of bisphenol A diglycidyl ether. The product obtained is viscous, is transparently clear, and possesses a weak yellowish coloration. Drawn down on a glass plate, it cures right through without any unpleasant odor nuisance.

Example 4 A

10 Preparation of a tris-azetidine based on Jeffamin T-403

In a reaction vessel with water separator 30 g (0.357 mol) of 3-methylcrotonaldehyde, 53.50 g (0.119 mol) of Jeffamin T-403 (Huntsman), and 0.1 g of p-toluenesulfonic acid are dissolved in 200 g of absolute toluene and the solution is heated to boiling. The reaction mixture is held at boiling temperature until water can no longer be removed via the water separator (theoretical: 6.42 g of water). Subsequently the toluene is removed completely. This gives a slightly orange-colored, resinous oil.

Example 4 B

Production of an NCO-containing prepolymer with the trisazetidine curing agent derivative from Example 4A

In a reaction vessel 250 g (0.125 mol) of polypropylene glycol Dow Voranol P3000 (from Dow) are held with 28.03 g (0.167 mol) of hexamethylene 1,6-diisocyanate and 0.1 g of T12-DBTL at 85°C until the theoretical NCO content of 2.52% by weight is reached.

Subsequently 36.03 g (0.0556 mol) of trisazetidine derivative from Example 4A are stirred into the NCO-containing prepolymer at room temperature.

35 The product obtained is resinous, is transparently clear, and possesses a weak orange coloration. Drawn down on a glass plate, it cures right through without any unpleasant odor nuisance. Even in a high-build application, curing takes place right through.

Example 5 A

Preparation of a bis-azetidine based on Jeffamin D-230

- 5 In a reaction vessel with water separator 30 g
(0.357 mol) of 3-methylcrotonaldehyde, 41.00 g
(0.178 mol) of Jeffamin D-230 (Huntsman), and 0.1 g of
p-toluenesulfonic acid are dissolved in 150 g of
absolute toluene and the solution is heated to boiling.
10 The reaction mixture is held at boiling temperature
until water can no longer be removed via the water
separator (theoretical: 6.42 g of water). Subsequently
the toluene is removed completely. This gives a
slightly orange-colored oil.

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Example 5 B

Formulation of an epoxy-functional resin with the
bisazetidine curing agent derivative from Example 5A

- 20 At 40°C 266.25 g (0.735 mol) of bisazetidine derivative
from Example 5A are stirred homogeneously into 250 g
(0.735 mol) of bisphenol A diglycidyl ether.
The product obtained is viscous, is transparently
clear, and possesses a weak yellowish coloration. Drawn
25 down on a glass plate, it cures right through without
any unpleasant odor nuisance.

Example 6

Storage stability test

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- The mixtures of prepolymers and latent curing agents
produced in accordance with Examples 1 to 5 are
subjected to storage in closed vessels at room
temperature (20-25°C), the results obtained being as
35 follows:

After a storage time of 12 months at a temperature
between 20-25°C in lightfast and airtight vessels, no
notable change in color was found for any of the
examples. The increase in viscosity over this period

was very low (increase by a factor in the range of 1.1-1.3 relative to the initial viscosity) and exhibited no effect at all on the curing or the processing properties.